6 METROLOGY, CONSULTATION, AND EMERGENCY RESPONSE

6.1 OVERVIEW

Harold L. Beck

The EML Metrology program consists of developing the generic instrumentation and analytical methods required to improve our overall measurement and analysis capability. It also includes a variety of quality assurance efforts designed to further the state-of-the-art of both EML's research, as well as environmental research carried out at other institutions. Also included in this section are projects associated with maintaining and improving the Laboratory's special facilities, such as the VAX Computer Center, the Technical Services Division Machine Shop and the Chester, NJ, field station. These facilities support many different EML research programs.

Because of the accumulated expertise and high reputation of the EML staff, we are frequently called upon by other agencies and institutions to provide advice and/or short-term assistance on potential or actual environmental contamination problems. We also are occasionally called upon to provide assistance in matters involving emergency response to environmental contamination. The major consultation activities in which we participated during 1995 and which continued to include important interactions with the Nuclear Regulatory Commission (NRC) are also discussed in this section. There were no significant emergency response activities during 1995.

6.2 INSTRUMENTATION DESIGN, DEVELOPMENT AND SUPPORT

Technical Services Division Staff

The Technical Services Division continued to provide design and support services for EML field and laboratory projects during 1995. This support included technical and design advice from the engineering staff, procurement of special equipment and supplies, aid in maintenance of facilities and computer links, as well as repair and maintenance, instrument modifications, and equipment assembly by the Machine Shop and Technical Services staff. Since the aforementioned support spanned most of the Laboratory's programs, only a few of the more significant efforts are listed below.

ARM Site Aerosol Sampling: The “statement of work” document, which was prepared at the Laboratory and includes detailed drawings and procedures to facilitate installation, received accolades from the ARM site personnel as among the best they have seen. Because of this, the installation of the articulating sampling stack and manifold, which was performed by a contractor, went very smoothly. To complete the testing initiated last year, Technical Services personnel modified commercial instruments, designed valve controls and interfacing circuitry and also completed the wiring and cabling along with the layout of the power busses. Once the complex array of instruments was tested, it was disassembled and shipped to the ARM site at Lamont, OK, where it was installed

by EML personnel (see Summary No. 4.2.)

Atmospheric Chemistry Program (ACP): This program, requiring several months of effort, involved the design and construction of three instrument packages: an automatic radon gas sampler, the "Radgrabber", and the aerosol measuring system (see Summary Nos. 5.3 - 5.5). These were successfully flown on the DOE G-1 aircraft this past summer. To facilitate this installation, a plywood mockup of the G-1 cabin was constructed to exactly locate the window probes as well as the floor mountings. This effort was rewarded when EML personnel were able to complete the installation of all three instrument packages in much less time than other project participants.

Remote Atmospheric Measurements Program (RAMP): The major effort in this program area was the construction of an Automatic Remote Atmospheric Measurements System (AUTORAMS) which was completed and successfully deployed at McClellan Air Force Base, Sacramento, CA (see Summary No. 1.4). In addition to designing the air sampler, counting shield, and gripping jaws, many corrections and modifications had to be made to the pick-and-place gantry which was supplied by a commercial vendor. These included new position sensors and extensive rewiring to install all the moving cables in movable wireways (looms) using special cables resistant to continuous flexing. Other major assemblies included the design and construction of the power supply, power management unit, computer interface, limit and crash switches, and diagnostic indicators. An operation and installation manual for the AUTORAMS was written for use by the test site personnel.

Other RAMP-related work included the installation of a new system at Pinedale, Wyoming, evaluation of new notebook computers, and construction of systems capable of both modem and/or satellite transmission. Support for other RAMP locations continued, with questions and difficulties resolved via FAX, E-mail, letters or phone. RAMPSCAN, a portable gamma radiation measurement and analysis system, was built and delivered. This unit is used to assay freshly collected aircraft filters to determine the likelihood of fission products having been collected. The entire RAMPSCAN is contained in a small suitcase and can operate on its rechargeable batteries for over four hours.

Electronic Development: Many of the instruments developed at EML require the "Tattletale" computer along with sensors. Rather than perform a custom layout each time, a general purpose unit was designed and built. This unit provides the circuitry for pressure, relative humidity, and temperature sensors. Also included is an analog expansion circuit which provides up to 30 analog channels. This is a low power design and is compatible with battery operation. Memory expansion is also provided.

Environmental Science Division Support: A TLD calibration stage was designed and built, and design work on a 4-meter long shadow calibration table was initiated. Additional modifications were made to the portable TLD reader described in last year's annual report (Azziz et al., 1995). For the high altitude neutron spectroscopy program, in addition to preparing the instrumentation, a multichannel temperature instrument was designed and built for the scintillation detectors. A portable tripod on wheels for making field measurements with liquid nitrogen-cooled Ge detectors was tested at a fixed dewar height. When complete, this assembly will have the capability of adjusting the dewar height.

Radon Detection Instrumentation Development: Construction of the Barrel Radometer (Negro et al., 1995) was completed. Tests with room air indicate that the unit is functional. However, determining the actual calibration requires further work in our standard radon chamber. Some additional testing on the air conditioner which controls the dew point is also required.

Some additional work was done on the flow-through Ionization Chamber Detector. A grid was added to indicate the presence of a desired alpha decay. This allows coincidence counting which improves noise rejection. However, the spectroscopy resolution obtained thus far has not been adequate and additional development is required.

General: The EML machine shop was upgraded with the addition of a large-bed heavy duty drill press. Our printed circuit Computer-Aided Design (CAD) facility was upgraded with the installation of PCAD version 8.0. Our technicians and machinists completed a total of well over 1000 work orders during 1995.

Other maintenance activities and/or improvement of Laboratory experimental equipment during 1995 included: (1) the completion of another shield for the Quality Assurance and Metrology Division's germanium diode gamma-ray counting facility; (2) expansion of the Laboratory's Local Area Network (LAN); (3) maintenance of the alarm system for the high-security room; (4) maintenance and repair of the Laboratory's perimeter alarm/smoke system, the 60 KVA uninterruptible power system for the EML computer facility, and the electron microscope facility. The staff also continued to maintain and support the EML Chester, NJ, regional baseline monitoring station.

References

Azziz, N. M. Polito, S. F. Guggenheim and V. C. Negro
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in: "EML 1994 Annual Report"
USDOE Report EML-571 (1995)

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"Barrel Radometer"
in: "EML 1994 Annual Report"
USDOE Report EML-571 (1995)

6.3 LABORATORY COMPUTER CENTER

Camille G. Marinetti, Robert Stocco and Jenny May

Facility Enhancements: An INTERNET connection including e-mail and World Wide Web capability was added to the Laboratory's computer facility, and a Sealeze 42C poster size laminator was added to the computer graphics equipment.

Computer Graphics: The computer graphics facility is available to EML personnel for the in-house production of slides, overheads, posters and high-quality prints. Users can create their own graphics on their IBM compatible or MacIntosh PCs, or give the Computer Group staff the raw material and have the finished graphic presentation done for them.

The graphics center printers and film recorder (for slides) are compatible with any Windows graphics software and most MacIntosh packages. A flatbed scanner and a slide scanner allow direct input of graphics, photographs, and textual material. The NovaJet poster printer can produce posters up to 2 feet by 3 feet. All printed output can be laminated if necessary.

DEC Pathworks LAN: The VAX cluster with the DEC VAX 6310 and 6410 computers supports approximately 80 users via an ETHERNET LAN and a system of servers throughout the Laboratory. PC users can communicate and share resources among the VAX, IBM compatibles, and MacIntosh computers using the DECNET protocol running over ETHERNET thin wire coaxial cables connected to the ETHERNET thick wire spine which runs around the Laboratory.

The DEC Pathworks PC LAN allows PC users to share files, printers, and software between network PCs and the VAX cluster. PCs attached to the LAN are able to use VAX printers and print queues, and to use PC software installed on the VAX disk drives which are available through the network. PC software currently installed on the LAN includes WordPerfect (DOS and Windows), Microsoft Word, PowerPoint, Harvard Graphics for Windows, Excel, Quattro Pro, Microsoft Access, FoxPro, Paradox for Windows, and Word for Word. A LAN-based backup package allows automated backups of PCs over the network during off-hours.

INTERNET Connection: The Laboratory's LAN is now connected to the INTERNET through a "firewall" server. The server provides e-mail and allows outward-bound World Wide Web, FTP, and TELNET access for the PCs connected to the Laboratory's LAN, while preventing unauthorized access from outside. It also provides an FTP site for the Laboratory (**eml.doe.gov**).

Most of the network PCs have been set up for INTERNET access, including the installation of the TCP/IP network protocol and an e-mail program, either Eudora or Pegasus. All employees also have access to World Wide Web browsers and FTP and TELNET programs for both Windows and MacIntosh.

The Laboratory has a World Wide Web server connected outside the firewall which provides access to the new EML Web site (**www.eml.doe.gov**) for information about major EML programs, downloading EML publications, and a searchable interface to the FY95 DOE Human Subjects

Research Database.

PC Repository:

The PC repository is maintained as a central pool of used computer hardware and software. When employees contribute items which they are no longer using, the item is added to the repository if it is in working order and can be of use to another person or if it is potentially valuable for replacement parts. The items are then distributed as needed.

6.4 DEVELOPMENT AND MAINTENANCE OF THE DEPARTMENT OF ENERGY HUMAN SUBJECTS RESEARCH DATABASE

Camille G. Marinetti and Lambros Kromidas

The Department of Energy (DOE) Human Subjects Research Database (HSD) contains information relating to research projects involving human subjects. These projects are funded by the Department of Energy, or are performed at DOE facilities with support from other sponsors, or performed by DOE personnel, or DOE contractor personnel. Research involving human subjects includes a variety of activities ranging from actual experimentation to simple questionnaires. The inception of this database resulted from the Secretary of Energy's "Openness Initiative" which declared that information about research involving humans must be made accessible to the public.

A computer program using Microsoft FoxPro was developed for collecting data on the use of human subjects in research at different DOE sites (see Summary No. 6.5). Both a hard copy questionnaire and computer diskettes, in Windows or MacIntosh format, were distributed as well as instructions and explanations to assist the investigators in completing the questionnaire. The information solicited relates to site information, funding, Internal Review Board (IRB) approval, where the study was conducted, who the investigators were, the number of human subjects involved in the study, description of the project, information on funding, and associated risks to the human volunteers.

After electronic completion of the questionnaire, the data files were copied onto a diskette. This diskette, along with a hard copy, was sent back to EML for proof reading and quality assurance. Subsequently, the information was incorporated into a database and printed in Hypertext Markup Language (HTML) for use on the World Wide Web. Finally, Common Gateway Interface (CGI) programs were written to allow World Wide Web users to search the database for keywords in the text portions of the project data or for specific types of use of human subjects (e.g., exposure to radiation, sampling of tissues, questionnaires, etc.). The database searches listings of all sites and accesses project information through the INTERNET address:

http://www.er.doe.gov/production/oher/humsubj/database.html.

Future plans include improvement of the data entry program to increase reliability and flexibility, to improve printouts, and to provide the ability to have sites enter data directly on-line through the World Wide Web.

6.5 FY 95 HUMAN SUBJECTS RESEARCH DATABASE

Lambros Kromidas, Camille G. Marinetti, and Merrill Heit

A searchable database was developed for DOE (see Summary No. 6.4) to describe research projects using volunteers. The database can be accessed in the World Wide Web under:

http://www.eml.doe.gov/hsr95/hsr1995.htm.

The DOE's FY 95 (October 1, 1994 - September 30, 1995) Human Subjects Research Database (HSD) contains information relating only to research projects involving humans that are funded by the DOE, performed at DOE research facilities, performed by DOE personnel, and/or by DOE contractors. The HSD contains detailed descriptions of each research study and provides information related to funding, where the study was conducted, who the investigators were, the number of human subjects involved in the study, description of the project, and associated risks, if any , to the human volunteers. The data is also presented in an abridged form for quick referencing. In addition, the database contains a glossary of scientific terms used to describe the research.

Some of the projects profiled in the HSD are therapeutic in nature; some are efforts to develop new instrumentation or techniques; some involve the use of trace quantities of radioactive material in imaging studies; others involve only the analysis of blood or urine samples from volunteers; and still others involve followup studies on workers previously employed at sites that stored or used radioactive materials. Other research projects are epidemiologic in nature, involving only the analysis of medical records of subjects to identify patterns of illness. As a result of reviewing thousands of anonymous records, a relatively large number of human subjects was added to the DOE HSD. To ensure that the database remains current, it will be updated regularly, both to add new information and to correct existing data if warranted.

Some general contents in the FY 95 HSD are:

- There are 35 reporting research facilities in the current database. Fourteen of these research facilities are DOE laboratories and 21 are non-DOE laboratories (such as Hospitals and Universities). Of the 35 reporting research facilities only one is located outside the United States and that one is in Italy (Azienda Ospedaliera Policlinico di Modena). The combined research facilities reported 225 projects, totaling $37,088,507. The number of human subjects that participated in these studies was approximately 30,858. Because epidemiological studies were included in this database, the total number of human subjects reported is not representative of actual people, but includes a large number of records from human subjects. In fact, 27,577 human subjects were part of 81 research projects that relate to epidemiological studies. The budget for these studies was $16,875,225. The 21 non-DOE facilities reported 28 projects with a budget of $11,522,138 and the participation of 4,711 human volunteers.

- Sixty-three of the 225 projects listed in this database were not supported by DOE grants. The reason these projects were listed in the DOE's Human Subjects Research Database was because the research was performed in DOE laboratories or by DOE employees. The budget

for these 63 projects was approximately $8,955,662 and they included 6,658 human volunteers.

- Twenty-two research projects reported this year received support from both DOE and non-DOE grants. The budget for these projects was approximately $9,193,557. The participation of human volunteers in these research projects was 1,700.

- Of the 35 research facilities listed in this database, Brookhaven National Laboratory reported the most projects. They reported 46 research projects with a budget of $4,472,500 and 856 human volunteers.

- Of the 225 projects listed in this database, approximately 64 involved human exposure to radiation. The nature of the exposure was therapeutic, clinical, or occupational. The number of human volunteers participating in these studies was 4,351 with a budget of $11,625,108. In all the studies, radiation was used either as a tracer to facilitate imaging, or for diagnostic and/or therapeutic reasons. DOE does **NOT** support any research in which the effect of radiation upon humans per se is the object of study.

6.6 ACTINIDE METROLOGY: CHROMATOGRAPHIC RESINS FOR THE ISOLATION OF ACTINIDES

Anna Berne

A new method for determination of americium in soil aliquots up to 50 g was presented at the Eichrom Industries, Inc. Annual User's Workshop held at the 41st Conference on Bioassay, Analytical and Environmental Radiochemistry on November 13, 1995 in Boston, MA. This method will also be presented at another User's Workshop in March 1996 in Belgium. It will also be publicized through an Eichrom Newsletter and eventually will be submitted for publication in a peer-reviewed journal.

The new method (Figure 6.1) combines the classical means of sample purification required by the larger aliquots of soil with time- and waste-reducing use of Eichrom Resin extraction columns. It is estimated that for a batch of four to eight samples, the number of man-hours for the americium analysis can be as little as 6.5 h. The total time for the determination is about four days, that is from the first oxalate co-precipitation to the point of submission for alpha-spectrometry. Table 6.1 compares results for determination of americium using this method with those obtained using the Am-06 Procedure (Berne and Greenlaw, in press).

Comment: The reported uncertainty is the standard deviation of the average. The individual determinations are based on enough counts so that the combined counting error (for the tracer and the analyte) is never more than 7% of the calculated value.

Reference

Berne, A. and P. Greenlaw
in: "EML Procedures Manual"
USDOE Report HASL-300, 28th Ed., Vol. 1, in press

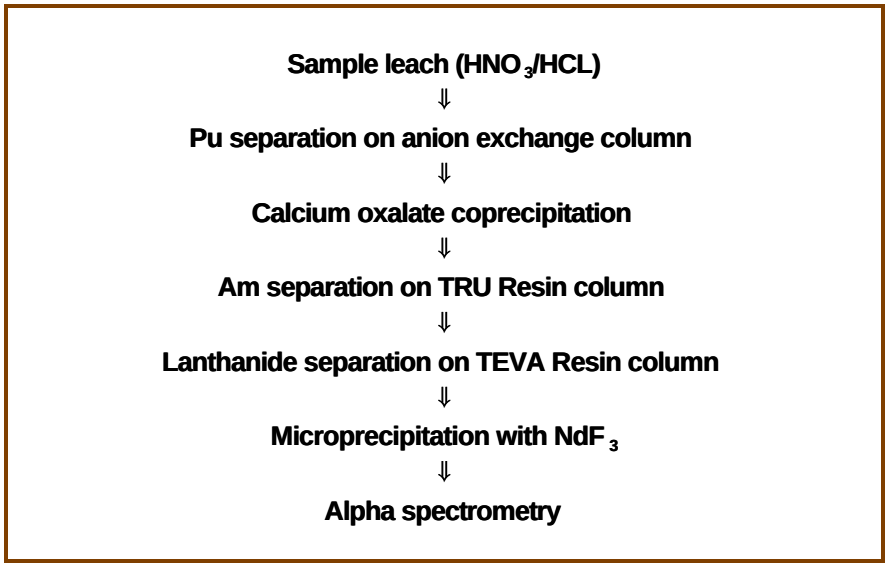
T A B L E 6.1

SUMMARY OF THE RESULTS OF ^{241}Am DETERMINATION IN SOIL ALIQUOTS UP TO 50 g

Sample size (grams)	mg Ca present	recovery of spike (%)	^{241}Am Bq kg^{-1}	$\theta_{\text{new method}}$ Bq kg^{-1}	$\theta_{\text{Am-06 procedure}}$ Bq kg^{-1}
Japanese ref. fallout material					
4	350	87	2.13	2.36 ± 0.14 (± 6.0%)	N/A
4	350	81	2.37		
4	350	70	2.40		
4	350	87	2.52		
4	350	82	2.38		
QAP 9309- Soil					
30	110	70	0.24	0.234 ± 0.006 (± 2.7%)	0.25
30	110	60	0.23		
QAP 9509-Soil					
20	200 + N/A	87	1.95	1.93 ± 0.18 (± 9.4%)	1.79 ± 0.07 (± 4%)
35	200 + N/A	73	1.75		
50	200 + N/A	61	2.11		

NOTE: Japanese reference material available from EML's participation in an intercomparison exercise with the Meteorological Research Institute in Japan.

a) New method:



b) Am-06 procedure:

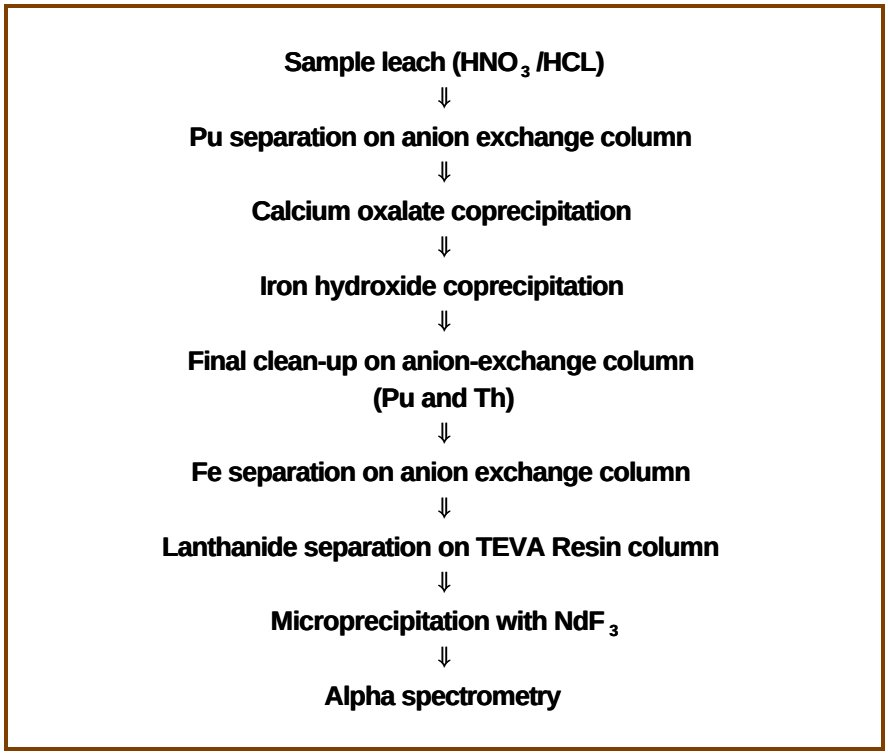


Figure 6.1 Flow Chart for Americium Separation in Soil.

6.7 RAPID DETERMINATION OF RADIUM BY SOLVENT EXTRACTION AND PERALS™*

Salvatore C. Scarpitta

The extraction efficiencies (EE's) of ^{226}Ra and its progeny ^{210}Pb/Po have been determined using a commercially available toluene based extractant under various chemical conditions. Six potentially interfering α emitting actinides (^{232}U, ^{230}Th, ^{244}Cm, ^{242}Pu, ^{243}Am and ^{237}Np) were also tested. Radium can be directly extracted from an aqueous sample with a 1-2 mL aliquot of RADAEX® and measured in a very low background PERALS™ α counting system that electronically rejects unwanted γ / ß signals. The extractant can also be mixed into either a toluene based or water miscible Liquid Scintillation (LS) cocktail and measured by conventional LS counting for rapid screening purposes. The EE of ^{226}Ra into RADAEX was 98 - 100% from a 0.3M $NaNO_3$ solution adjusted to pH > 10, whereas that of ^{210}Pb/Po was 2-3%. The EE's for ^{226}Ra, ^{210}Pb/Po and the 6 actinides were also measured over a pH range of 1 to 12. Of the 6 actinides, only Cm and Am co-extracted at pH > 10 with EE's of 100% and 63%, respectively. These 2 actinides, if present in a sample, cannot be back-extracted from the Ra bearing organic phase by simply changing the pH or acid concentration without loss of Ra isotopes. Americium or Cm, if present, would interfere with the determinations of either α emitting ^{223}Ra (5.6 MeV), ^{224}Ra (5.7 MeV) or ß emitting ^{228}Ra (via ^{228}Th progeny; 5.3 MeV α) but not that of ^{226}Ra (4.8 MeV α) because of the 0.250 MeV α energy resolution of the PERALS™ Spectrometer. Gamma emitting ^{133}Ba, which may be used as a yield determinant, is not detected by PERALS™. This work was presented at the 29th Midyear Health Physics NORM (Naturally Occurring Radioactive Materials) Topical Meeting, in Scottsdale, AZ, in January 1996.

* Ordela, Inc., Oak Ridge, Tennessee

6.8 SOLID PHASE SCINTILLATION COUNTING OF α, β AND γ EMITTING RADIONUCLIDES USING PLASTIC SCINTILLATING POLYMER BEADS

Salvatore C. Scarpitta and John Kada

As a waste minimization alternative, gram amounts of two commercially available plastic Beaded Scintillation Materials (BSMs) are being investigated and compared to a commercially available water-miscible liquid scintillant using selected NIST traceable α, ß and γ emitters. These beaded polymers can be used in selected applications to significantly reduce the mixed-organic liquid waste generated from routine Liquid Scintillation (LS) counting of aqueous environmental samples. Conventional LS counting requires 5-20 mL of LS cocktail per sample, producing a non-reusable mixed-waste end product.

The first of the 2 BSMs, a polyvinyltoluene (PVT) polymer* with 100-250 μm diameter, produces 425 nm photons that are detected by a Packard Tri-Carb 2250-CA LS Analyzer# with 90-94% counting efficiency (CE) when 5 or 10 gm of the dry polymer was mixed with 1 gm ^{40}KCl (1.320 MeV $ß_{max}$ as a chloride salt; 851 dpm ^{40}K g^{-1} KCl) in either 20 mL glass or plastic counting

vials. The CE dropped to 70% when 0.5 gm of the dry material was used. When water was added to the ^{40}KCl/BSM mix, the CE ranged from 60-90%, depending on the weight ratio mix of BSM to water. An 84% CE was obtained when 2 gm of the PVT material was slurred with 1 mL of the KCl solution.

The second BSM (of comparable size and density) was a polyvinyl benzene (PVB) polymer containing 5% divinylbenzene as an additive. It yielded a maximum CE of 72% when 0.5 - 1.0 gm of the dry material was mixed with 1 gm ^{40}KCl. The CE was reduced by a factor of 2 when 10 gm of the dry PVB material was mixed with ^{40}KCl. As with the PVT material, the optimum mix of polymer to KCl solution was 2:1 for the PVB material.

The relationship between CE and beta energy was linear for both BSM's using 5 pure ß emitters whose E_{max} ranged from 0.245 MeV (^{45}Ca) to 3.50 MeV (^{106}Ru). Using 2 gm of PVT beads with 1 mL of the aqueous solution of the nuclides, the CE increased from 22% (for ^{45}Ca)) to 100% (for ^{106}Ru). Using ^{244}Cm (5.2 MeV) as an α source, the α-CE for the dry PVT material was 65%, whereas that of the dry PVB material was 95%. When washed with water, neither material retained any previously added α or ß activity.

[*] Bicron Corp., 12345 Kinsman Rd, Newberry, OH. 44065
[#] Packard Instrument Co. Downers Grove, IL.
[+] Duke Scientific Corp. 2463 Faber Pl., PO Box 50005, Palo Alto, CA. 94303.

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Harley, J.H.; N.A. Halden and I.M. Fisenne
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Nucleonics, 20:59-61 (1962)

Scarpitta, S. C.; and I. M. Fisenne
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Int. J. Appl. Rad. Isotopes, in press

6.9 PLASMA SPECTROMETER UPGRADE

William C. Rosa

Our plasma spectrometer capability was upgraded via the integration of several pieces of new hardware. Installation of an Analytical Data Manager and an Ultrasonic Nebulizer was completed. The preliminary results of these improvements to the plasma spectrometer are: (1) an increased data collection capability by a factor of 10; (2) an improved signal-to-noise ratio by a factor of 5 for many of the analytes of interest; and (3) a substantial reduction in use of consumables, for example argon gas. These improvements will decrease both sample analysis time and operating costs.

6.10 GAS CHROMATOGRAPHY/MASS SPECTROMETRY

Raymond J. Lagomarsino

A KRATOS high resolution magnetic sector gas chromatograph/mass spectrometer has been installed in a temperature and humidity controlled facility. The analyzer is a double focusing Nier-Johnson geometry, consisting of a 90° electrostatic analyzer with a mean radius of 135 mm and a 60° magnetic analyzer with a mean radius of 205 mm. Operable range is from 2μ to 4000μ. Source capabilities include electron impact and positive/negative chemical ionization. Instrument control, acquisition and data processing is by a Sun Microsystem SPARC-station computer (UNIX).

The system is being evaluated for the measurement of volatile organic compounds in performance evaluation samples for DOE's Mixed Analyte Performance Evaluation Program (MAPEP). Applicability of the system for EPA Method 8260A will be investigated. A HP-7695 Purge and Trap System is available for installation once the acceptance criteria have been met.

6.11 GAMMA-RAY SPECTROMETRY

Colin G. Sanderson, William Rivera, Karin M. Decker

Low level environmental gamma-ray spectrometry is often complicated by a wide variety of sample matrices, different types of detectors and numerous counting geometries. Environmental samples collected for gamma-ray spectrometry usually consist of soil, vegetation, tissue, water or air particulates. These samples may range in size from a few grams or cubic centimeters to many kilograms or liters. Gamma-ray spectrometry at EML is performed with nine high resolution germanium detectors in five different configurations. These consist of three 1.5 cm diameter wells, a 2.54 cm well, a 1.5 cm well in a segmented germanium detector with a sodium iodide Compton suppression shield, four n-type low energy coaxial, and a 2000 square centimeter planar detector. Gross gamma-ray screening is obtained from the events detected with the coaxial germanium systems. Four different counting geometries are routinely used for quantitative analysis. These are 600 cubic centimeter Marinelli (reentrant) beakers, 90 cubic centimeter aluminum cans, 45 cm^3 plastic planchettes and 1 to 2 cm^3 samples in plastic test tubes for well counting.

During the past year, 924 filter samples from the Environmental Science Division's Surface Air Sampling Program (see Summary No. 1.3) were routinely analyzed with germanium detectors for ^{7}Be, ^{95}Zr, ^{137}Cs, ^{144}Ce and ^{210}Pb. In addition, over 1231 QAP samples, intercomparisons and miscellaneous samples were analyzed for a variety of gamma-ray emitters using these systems.

6.12 *IN SITU* GAMMA-RAY SPECTROMETRY

Kevin M. Miller, Peter Shebell, Marcel Reginatto and Gladys A. Klemic

The technique of gamma-ray spectrometry as applied directly in the field for assessing environmental radiation and radioactivity has been refined and applied to many studies by EML researchers over the course of four decades. Since the technique has the potential to expedite radiological surveys in support of environmental restoration, it is receiving increased attention. This past year, we provided consultation to 22 different organizations seeking guidance on performing *in situ* spectrometric measurements for site characterization and remediation control. In the interest of further spreading the use of this technology, we organized and taught a short course on *in situ* gamma-ray spectrometry for the IEEE Nuclear Science Symposium held in San Francisco in October. This was the fourth time in the past five years we have given this course at the request of the IEEE. In this time span, close to 100 individuals from various private companies and government and international organizations have taken this course.

In 1995, EML was under contract to the Nuclear Regulatory Commission to provide guidance and support for applying *in situ* spectrometry to measuring residual radioactivity during decommissioning surveys. We demonstrated the technique during two surveys and also provided a one-day training program (see Summary No. 6.20). Demonstration to DOE contractors was also provided at the Weldon Spring Remedial Action Site (see Summary No. 6.13).

The International Commission on Radiation Units and Measurements (ICRU) issued its report on *in situ* gamma-ray spectrometry in 1995. This work was the collaborative effort of a six member committee with individuals from five different countries, including an EML scientist who represented the U.S. The committee began its work in 1991 and final editing and review of the report was completed in 1994 (ICRU, 1994). This report will serve as a primer for the beginner and as a general reference for the expert field spectroscopist. Also, as an international consensus report, it will provide impetus in having this measurement technique gain wider acceptance in the regulatory community.

Reference

International Commission on Radiations Units and Measurements
"Gamma-Ray Spectrometry in the Environment"
ICRU Report 53 (1994)

6.13 DEMONSTRATION OF *IN SITU* GAMMA-RAY SPECTROMETRY AT WELDON SPRING SITE REMEDIAL ACTION PROJECT

Peter Shebell and Kevin M. Miller

The Weldon Spring Site Remedial Action Project (WSSRAP) in Weldon Spring, Missouri, requested an on-site demonstration of *in situ* gamma-ray spectrometry. WSSRAP has several possible applications for *in situ* gamma-ray spectrometry for determining concentrations of uranium and thorium in surface soils. These applications range from excavation control during soil remediation to a reduction in the number of conventional confirmation samples. WSSRAP staff was also interested in the technique for use in addressing areas that are not amenable to standard sampling techniques. EML provided DOE personnel and contractors with an overview of *in situ* gamma-ray spectrometry and a demonstration of the technique along with an interpretation of the *in situ* results as they compare to traditional soil sampling methods. (See Figure 6.2).

Three sites were used for the demonstration. One site was believed to be at or near background levels for uranium and thorium, while the other was above background but below the action level. The third site was a wooded area several miles from the facility known as the southeast (SE) drainage ditch. With the exception of the drainage ditch, the measurements were performed on a grid which approximated the sampling grid described in WSSRAP's cleanup confirmation plan (USDOE, 1994). Each grid consisted of five measurement points, one at each corner of a 20 m square with one at the center. Measurements at the SE drainage ditch were taken at points believed to be contaminated with thorium.

In addition to the standard 1-meter measurements, a series of shielded measurements was performed at about 15 cm from the ground. It was anticipated that these "point" measurements would replace a significant fraction of conventional confirmation samples. A total of 20 (shielded and unshielded) *in situ* spectra was collected and analyzed over the course of three days. Measurements of the total exposure rate from penetrating radiation (cosmic and terrestrial) were also made at the grid points with a pressurized ionization chamber. These measurements serve as a component of quality assurance for the 1-meter measurements. The demonstration concluded with a presentation of preliminary results. The *in situ* results of uranium concentrations were consistent with previous measurements taken at or near the measurement locations. Subsequent soil samples taken at the measurement locations show good agreement with *in situ* results for uranium. WSSRAP is currently considering the technique to reduce the number of conventional confirmation samples.

Reference

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Figure 6.2 An in-situ gamma-ray measurement at the Weldon Spring Site Remedial Action Project (WSSRAP) in Weldon Spring, Missouri.

6.14 ANALYSIS OF *IN SITU* MEASUREMENTS ON A GRID

Marcel Reginatto, Peter Shebell and Kevin M. Miller

In situ spectrometric measurements can be performed on a square or triangular grid to ensure complete coverage of extended areas that are potentially contaminated with radionuclides. While such measurements will provide valuable information on the spatial distribution of the contaminant, the problem of reconstructing the real distribution of activity on the ground from a finite number of measurements is ill posed and the solution is not unique. Difficulties also arise due to the experimental errors associated with the set of measurements.

An important element in surveys of residual radioactivity is the detection of localized areas of elevated contamination, sometimes referred to as “hot spots”. We have developed a computer code that analyzes a series of *in situ* measurements on a grid and searches for distributions of activity (possibly many) that fit the data and on which a hot spot is present. The algorithm makes use of a preliminary deconvolution of the data using the maximum entropy method (Skilling and Bryan, 1984), followed by further analysis which results in solutions each with the largest possible hot spot at a given location over a smooth background. The algorithm is quite general and could be modified for use in other types of measurements. The computer code is designed to be used as a tool when evaluating compliance with regulations that set limits on hot spots and is, therefore, designed to identify those "worst case scenarios" where a hot spot might be present.

Properties of the algorithm were investigated using simulated data as well as actual measurements. In one field test, a 24.05×10^3 γ/s Cs-137 check source was used to simulate a hot spot, and 35 equally spaced measurements were taken on a rectangular 7m x 5m grid with measurement points 2.44 m apart. Figure 6.3 shows the output from the preliminary maximum entropy deconvolution, while Figure 6.4 shows the final surface activity distribution that corresponds to the largest single potential hot spot over a smooth background (both are good solutions in the sense that they both fit the data). While the maximum entropy solution shows structure that reflects the grid geometry (with the peaks centered exactly at measurement points where there is an excess of activity), the solution with the largest hot spot has only one large peak that falls between measurement points. The code placed the largest potential hot spot within 0.67 m of the actual location of the check source. In another successful application, the code was used to analyze measurements on a triangular grid at a facility where depleted uranium was used in industrial operations. This last application is related to Nuclear Regulatory Commission decommissioning criteria work in progress at EML (see Summary No. 6.20).

Part of this work was presented at the IEEE 1995 Nuclear Science Symposium and Medical Imaging Conference and a paper was submitted for publication (Reginatto et al., in press).

References

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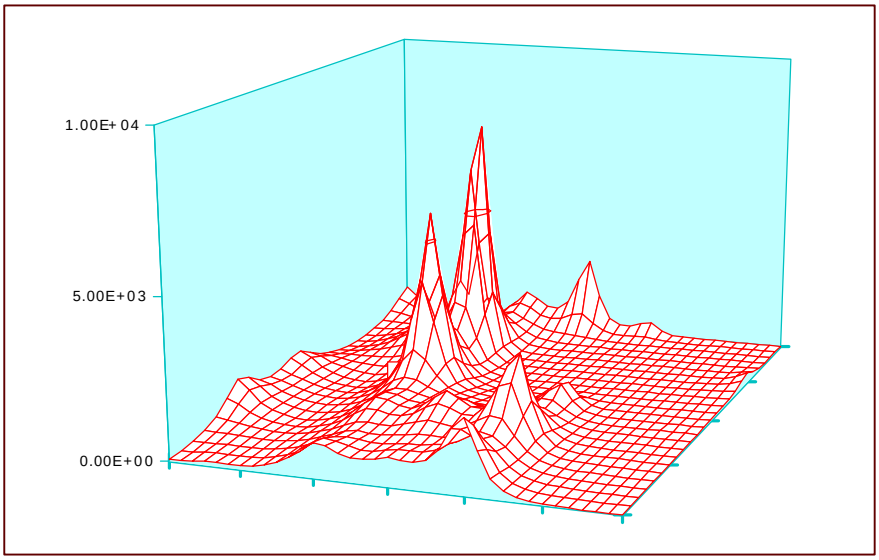

Figure 6.3 Surface activity distribution (γ/s/m^2) from the maximum entropy deconvolution of the data

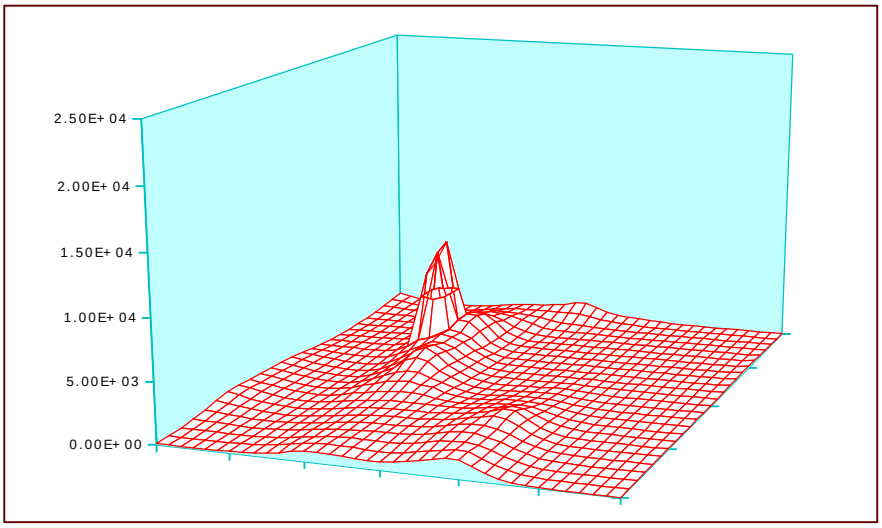

Figure 6.4 Surface activity distribution (γ/s/m^2) corresponding to the largest potential hot spot over a smooth background.

6.15 SEMI-EMPIRICAL METHOD FOR DETERMINING THE ANGULAR RESPONSE FOR Ge DETECTORS

Peter Shebell and Marcel Reginatto

The calibration of a coaxial Ge detector for *in situ* spectrometry involves the determination of its angular response. The current EML procedure to measure this quantity is simple, but time consuming. It requires a series of measurements which are fitted to a polynomial for a few calibration energies. Spurious results can occur when poor statistics for weak gamma emitters cause fluctuations in the data which are incorporated into the polynomial fits. Subsequent interpolation and extrapolation of the angular response for a given energy is difficult and subject to error.

A general procedure for determining the angular response for coaxial Ge detectors is being developed which incorporates the basic physics of photon interactions within the active region of the crystal. The approach is based on the work of Moens et al. (1981) and Wang et al. (1995) in connection with the calculation of the absolute-peak-efficiency for HPGe detectors for various counting geometries. Their semi-empirical method involves the measurement of the efficiency of the detector for a reference geometry as a function of energy and the calculation of an effective solid angle for an experimental reference configuration. The efficiency for a particular configuration is then expressed in terms of the ratio of effective solid angles and the efficiency for a reference geometry.

In similar fashion, the angular response of a HPGe detector for an *in situ* measurement , $R(\theta)$, can be expressed as the ratio of effective areas:

$$R(\theta) = A_\theta / A_{\theta=0^\circ}$$

where A_θ is the effective area for a parallel beam of photons incident on the detector with an angle θ relative to the symmetry axis of the crystal. A_θ is defined as

$$A_\theta = \int_S (P\phi_{eff})\ \mathbf{n}\cdot d\mathbf{S}$$

where P is the probability that a photon passing through a differential surface area, $\mathbf{n}\cdot d\mathbf{S}$, will scatter incoherently in the active region of the crystal; ϕ_{eff} is the photon fluence rate adjusted for scattering by materials in the detector.

Preliminary results for a p-type closed end coaxial detector with a relative efficiency of 17.6% and a crystal length-to-diameter ratio of 0.57 indicate that this new approach will agree with measured data within 6%. While errors of this magnitude do not contribute significantly to the total uncertainty, improved computational methods should bring agreement to better than 3%.

References

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"Calculation of the Absolute Peak Efficiency of Gamma-Ray Detectors for Different Counting Geometries"
Nucl. Instrum. Meths., 187, 451-472 (1981)

Wang, T. K., et al.
"HPGe Detector Absolute-peak-efficiency Calibration by Using the ESOLAN Program"
Appl. Radiat. Isot. 46, 933-944 (1995)

6.16 EML HOSTS THE 6TH INTERNATIONAL RADON METROLOGY PROGRAM (IRMP) INTERCOMPARISON TEST AND WORKSHOP

Adam R. Hutter and Earl O. Knutson

EML was host to the 6th IRMP Intercomparison Test and Workshop titled "State of the Art in Measuring Soil Gas Radon and Radon Exhalation From Soil", June 12 - 15, 1995, the week following the Natural Radiation Environment VI Symposium. Twenty-six (26) participants representing 11 countries and 23 different institutions attended the workshop. Three different activities were planned for the week: a day of seminars and discussions, a day of laboratory measurements of radon flux and high-concentration grab samples, and a day of field measurements of radon flux and soil gas radon. The first day included nine presentations, with ensuing discussions, aimed at addressing the question of whether the current state-of-the-art in measuring soil gas radon and radon flux from soils meet the precision and accuracy requirements for applications of these measurements. The laboratory and field exercises were designed to quantify the intercomparability of different methods and instruments used by different researchers. During the laboratory day, a Ra-spiked concrete slab was used as a standard for radon flux measurements. Likewise, ^{220}Rn and ^{222}Rn grab samples were obtained from the source drum. The day of field exercises was held in an open grassy meadow at Cheesequake State Park in Matawan, NJ, where radon flux from the surface and soil gas measurements was obtained. The soils at the site are known to be fairly homogeneous, an important consideration for intercomparison exercises.

There was a general consensus among the participants that the precision and accuracy needs for a particular application for both radon flux and soil gas radon dictate the methods and instruments that should be used. There are instruments currently available, either commercially or strictly for research, to ensure proper and appropriate measurements (i.e., precision and accuracy needs) for virtually any application, if prudently chosen.

The results of the laboratory and field exercises show excellent agreement among the participants when comparing source drum and exhalation measurements, both from the slab and in the field, but soil gas measurements were scattered, with a greater than three-fold variation, largely attributed to errors introduced during sampling rather than calibration or counting errors.

A report will be published by the International Atomic Energy Agency (the sponsor for the IRMP) with a condensed version being submitted as an article to a peer-reviewed journal. There was also consensus on the importance of holding another similar intercomparison and workshop, perhaps in conjunction with the next NRE meeting. Topics suggested for the next workshop include studying the importance of soil permeability on soil gas radon measurements, as well as measurements of soil emanation. Figure 6.5 shows scientists performing radon flux measurements at the Cheesequake State Park during the 6th IRMP Intercomparison Test and Workshop. Figure 6.6 is a group photo of IRMP6 participants.

Figure 6.5 Scientists performing radon flux measurem
6th IRMP Intercomparison Test and Workshop hosted by EML, June 12 - 15, 1995.

Figure 6.6 Group photo of IRMP6 participants.

6.17 PARTICIPATION IN THE IAEA'S MISSION TO KAZAKHSTAN

Adam R. Hutter and Peter Shebell

The final report on EML's participation in the International Atomic Energy Agency's (IAEA) Mission to Kazakhstan, "Strengthening Radiation and Nuclear Safety Infrastructures in Countries of the Former USSR, Special Task - Pre-assessment of the Radiological Situation in the Semipalatinsk and Western Areas of Kazakhstan", was submitted to the IAEA. During July 1994 a 10-member team, with participants from France, UK, Austria and Russia, visited sites within the Semipalatinsk Nuclear Test Site as well as several surrounding villages. Specifically, the objectives of the EML team were to apply independent methods and equipment to assess potential current radiation exposures to the population. Towards this end, the EML scientists collected *in situ* gamma-ray spectra, performed external gamma dose rate measurements using pressurized ionization chambers, and collected soil samples in order to estimate the inventory and to determine the depth distribution of radionuclides of interest. The report, "Environmental Radiation Measurements at the Former Soviet Union's Semipalatinsk Nuclear Test Site and Surrounding Villages," will be published as an EML Report and in a condensed form will be submitted for publication in a journal. Figure 6.7 shows an EML scientist performing field measurements near ground zero at the Semipalatinsk Nuclear Test Site, Kazakhstan.

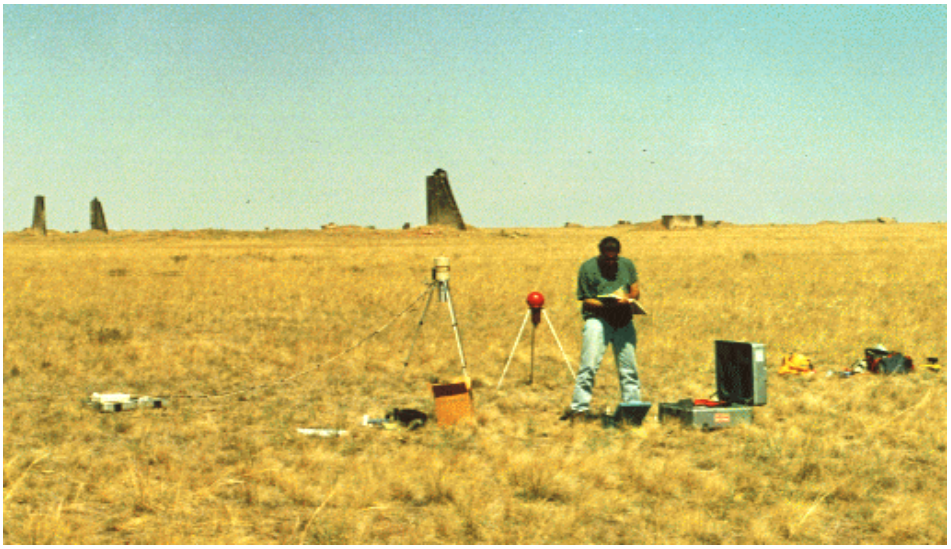

Figure 6.7 EML scientist performing field measurements near ground zero at the Semipalatinsk Nuclear Test Site, Kazakhstan.

6.18 FIELD INVESTIGATION AT CHELYABINSK-65

Karen A. Stevenson

Since early 1994, EML has been participating in the joint Russian - United States subsurface contaminant transport study conducted under the auspices of the Joint Coordinating Committee for Environmental Restoration and Waste Management (JCCEM) between the DOE Office of Environmental Management (EM) and the Russian Ministry of Atomic Energy (MINATOM). Other participating U.S. laboratories have included Savannah River Laboratory (SNL), Pacific Northwest National Laboratory (PNNL) and Lawrence Berkeley Laboratory (LBL).

In September of 1994, the first joint Russian - U.S. field site investigation was conducted under the JCCEM in the territory of the Mayak Production Association, 13 km southwest of Ozersk (formerly Chelyabinsk-65) (Wollenberg et al., 1995). The purpose of this field site investigation was to examine the frontal area of a contaminated groundwater plume moving from the disposal site, Lake Karachai, toward the Mishelyak River. Activities during this first joint exercise included (1) isolation of hydrologic intervals in two wells and the production of water from these isolated intervals in order to compare isolated versus open-well sampling methods and to determine hydraulic transmissivities of the aquifers; (2) surface and soil-water sampling, accompanying radiometric measurement and subsequent chemical analyses; and (3) electrical resistivity profiling in areas of expected contrasting resistivity using a conventional dipole-dipole array survey instrument.

The EML team members, Karen Stevenson (Federal Technical Lead) and Wayne Lowder (consultant), were tasked with providing the U.S. team with both real-time and passive dosimetry and conducting *in situ* gamma-ray spectrometry measurements along the Mishelyak River. Figure 6.8 is a schematic of the field site. Locations listed as PT0 - PT7 indicate where Russian - United States comparative field site radiometric measurements were made, and locations listed as W1 - W7 indicate where surface river water grab sampling and *in situ* radiometric measurements were conducted. Also shown in Figure 6.8 are the approximate location of the Mishelyak River and other site-identifying features.

Results of the field site radiometric measurements (PT0 - PT7) indicate that the free-air dose exposure rate at this location is approximately three times higher than what would be expected from natural gamma-ray emitters. Investigation of the spectra indicate that ^{137}Cs was the most significant contributor to the excess external dose exposure at an average deposition of 126 ± 26 (1 SD) kBq m^{-2}. Likely source terms of this anthropogenic radionuclide include past weapons testing, global fallout and a 1967 incident involving a surface repository (Stevenson, 1994).

Russian laboratory results of grab water samples obtained at different locations along the Mishelyak River detected the presence of ^{60}Co at concentration levels that were less then 1.5 Bq l^{-1}, 0.1% of the present day permissible concentration level for radiation safety in Russia. As shown in Figure 6.9, the *in situ* gamma-ray water measurements conducted by the U.S. team in the Mishelyak River closely resemble a half-space geometry (2π). Calibration of the spectra, using this half-space geometry, corroborated the findings of the Russian laboratory results to within an order of magnitude.

Findings of the Russian - U.S. activities during the field site investigation, including the EML radiometric measurements, are contained in the following reports:

"Joint Russian-American Hydrogeological-Geochemical Studies on the Karachai-Mishelyak System, South Urals, Russia" (submitted to the Journal of Environmental Geology, 1996);

"Resistivity and Induced Polarization Survey at a Russian Nuclear Waste Site" (submitted to Geophysics, 1996); and

"Joint Russian-United States Radiometric and Surface Water Chemistry Measurements with the Karachai - Mishelyak System, Southern Urals, Russia" (submitted to the Journal of Environmental Radioactivity, 1996).

In July of 1996, a second joint Russian-U.S. field site investigation will be conducted in the territory of the Mayak Production Association.

References:

Stevenson, K.A.
"Some Aspects of Radioactive Contamination Within the Former USSR"
in: “Managing Radioactive and Mixed Wastes”, Proceedings of the Twenty Seventh Mid-Year Topical Meeting of the Health Physics Society, Albany, New York, pp. 337-380, July (1994)

Wollenberg, H., C.-F. Tsang, W. Frangos, R. Soubau, W. Lowder, K. Stevenson, M. Foley, E. Drozhko, G. Romanov, Y. Glagolenko, A. Posochov, Y. Yvanov, L. Samsonova, A. Petrov, S. Ter-Saakain, N. Vasil'kova, and A. Glagolev
"A Joint Russian - American Field Test at the Chelyabinsk-65 (MAYAK) Site: Test Description and Preliminary Results"
“Management of Low-Level Waste and Remediation of Contaminated Sites and Facilities,” Fifth International Conference on Radioactive Waste Management and Environmental Remediation, ICEM'95 **2**, pp. 1381-1386 (1995)

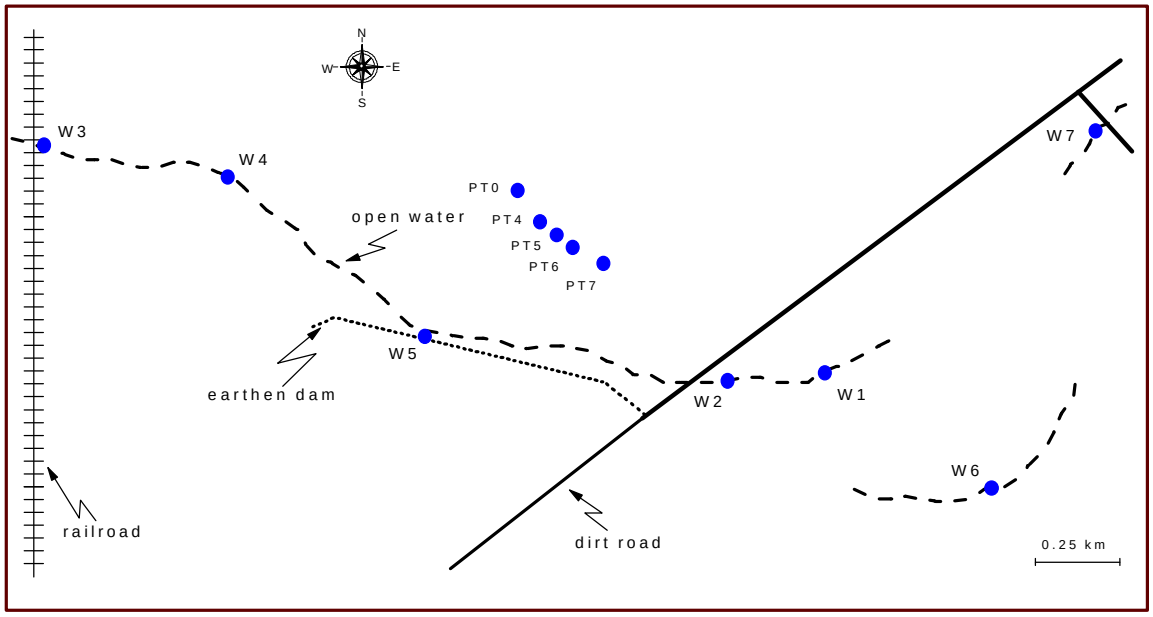

Figure 6.8 A schematic of the field site. Marked in dots (●) as PT# are locations where radiometric measurements were conducted. Marked in dots (●) as W# are locations where both radiometric measurements were conducted and water samples obtained. Also shown, are an access dirt road, a railroad tracks, an earthen dam and open water of the Mishelyak River.

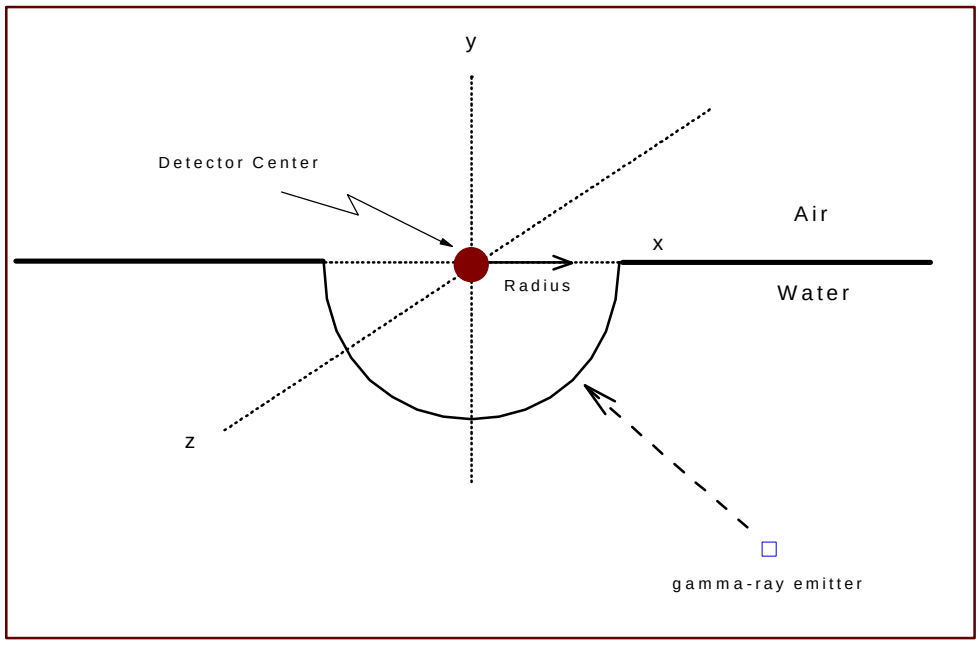

Figure 6.9 Schematic for calculating the photon fluence rate per activity in water for the *in situ* gamma-ray spectrometry measurements using a half-space geometry.

6.19 RADIOLOGICAL EVALUATION OF THE CONSTRUCTION SITE FOR THE FISSILE MATERIAL STORAGE FACILITY IN RUSSIA

Karen A. Stevenson

In June 1995, at the request of the Defense Nuclear Agency (DNA), EML participated in a radiological evaluation of the construction site for the Fissile Material Storage Facility (FMSF) located within the territory of the Mayak Production Association in Russia. The DNA requested a health and safety survey to assess the potential radiation exposure to U.S. personnel who will participate in the delivery, training and maintenance of construction equipment. Support for the construction of the FMSF at Mayak is through a collaborative project between the Department of Defense (DoD) and the Ministry of Atomic Energy for the Russian Federation (MINATOM) to build secure storage facilities for excess Russian weapons materials. United States participants for this evaluation included personnel from DNA, the U.S. Army Center for Health Promotion and Preventive Medicine, the U.S. Army Corps of Engineers and the Department of Energy's Environmental Measurements Laboratory.

A possible source of anthropogenic radionuclide contamination at the construction site was a 1967 incident at a surface radioactive waste repository, which dispersed almost 20 TBq (600 Ci) of radioactive silt over an area of 2700 km^2. At the time of the June 1995 survey, the Russians had removed the top 15 - 30 cm of soil from the construction site. A radiological survey revealed that the radiation levels do not pose any immediate danger to personnel. The exposure levels were found to be less than < 10 μR hr^{-1}, with a few isolated locations exceeding 50 μR hr^{-1}. Recommendations of the evaluation team included: (1) a request for the Russians to remove the remaining contaminated soils at the construction site; (2) continuous air monitoring employed on the site during the time of personnel occupancy; and (3) U.S. personnel should undergo baseline bioassay performed prior to being deployed to the site and periodically thereafter (every 90 days).

6.20 SUPPORT FOR NRC DECOMMISSIONING RULEMAKING

Kevin M. Miller, Carl V. Gogolak, Peter Shebell, Gladys A. Klemic, and Marcel Reginatto

Since 1993, EML has been under contract to the Nuclear Regulatory Commission (NRC) to support the implementation of a rulemaking on new decommissioning criteria. The proposed criteria for unrestricted release of a licensed facility would be a limit of 0.15 mSv (15 mrem) total effective dose equivalent per year to the average member of a critical group from residual radioactivity that is distinguishable from background. Our work initially dealt with a compilation of information on background radiation, its components and spatial and temporal variations, as well as the costs associated with making measurements of residual activity at concentration levels approaching those found in background. This provided necessary information for the preparation of the draft Generic Environmental Impact Statement to support the rulemaking.

Subsequently, EML was tasked to prepare guidance documents for the methodology to be employed in final status surveys. In 1995, the writing and editorial and technical reviews for two NUREG documents were completed and these were then published by the NRC as drafts for comment. The first document (Gogolak et al, 1995) deals with the overall final status survey design using a Data Quality Objective (DQO) approach and the requisite non-parametrical statistical tests that would be employed to judge whether an area undergoing decommissioning meets release criteria. This methodology should allow for relatively efficient survey designs compared to present draft guidance as, in general, smaller numbers of samples or measurements are required. At the same time, it provides a flexible approach in providing a defensible basis for release based on hypothesis testing and the setting of desirable type I and II error rates. The second document (Huffert and Miller, 1995) deals with the supporting measurement methodology that can be employed given the default concentrations associated with the 0.15 mSv per year dose level. Although the task of measuring residual radioactivity will be more difficult at low concentration levels, the application of nuclide specific field measurements, as with high resolution gamma-ray spectrometry, will generally provide the necessary sensitivity. The statistical and measurement methodologies were presented by EML staff at a public workshop held in September 1995 at NRC headquarters in Rockville, MD.

In addition to the methodology development, EML provided training to the NRC staff and their contractors on *in situ* spectrometric methods and non-parametrical statistical tests. As a training exercise and to further refine the methodology, demonstration surveys were performed at two facilities. One was a power reactor (see Figure 6.10) where the critical nuclides of concern were ^{60}Co and ^{137}Cs. Both an indoor and outdoor survey unit were measured using reference areas for comparison. Measurement methods employed included gross surface activity readings with a GM survey meter, total exposure rates readings using a pressurized ionization chamber, soil sampling followed by laboratory analyses, removable activity measurements using smears and *in situ* gamma-ray spectrometry. The second survey demonstration involved an outdoor survey unit at a facility where depleted uranium was used in industrial operations. In place of a reference area, the background ^{226}Ra was assessed at each measurement point to infer the "excess" ^{238}U present. Since standard scanning sensitivity was not adequate at the proposed release levels in this case, a closely spaced grid of *in situ* spectrometric measurements using a large volume Ge detector was used along with a deconvolution routine developed by EML to check for elevated area contamination (see Summary No. 6.14).

Additional development work in the decommissioning area is ongoing. This past year, one sample non-parametric tests were refined and incorporated in the recommended methodology for those situations where background is negligible and reference areas need not be chosen. Also, a median test was developed for those situations where the statistical tests indicate that radioactivity distinguishable from background is present, but where the distribution of measured concentrations suggests an average dose less than 0.15 mSv per year. Work also progressed on applying *in situ* spectrometry for assessing residual radioactivity on surfaces inside buildings. Future work will include addressing issues of biased sampling and resampling and applying unfolding routines for *in situ* spectrometry performed inside buildings to assess elevated surface area contamination.

References

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"A Non-Parametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys"
USNRC Report NUREG-1505 (draft) (1995)

Huffert, A. M. And K. M. Miller
"Measurement Methods for Radiological Surveys in Support of New Decommissioning Criteria"
USNRC Report NUREG-1506 (draft) (1995)

Figure 6.10 EML scientists using a collimated Ge gamma-ray spectrometry system and a GM survey meter for assessing residual surface contamination during a demonstration of newly developed final status survey methodology at a nuclear power plant.

6.21 NRC/CEC CONSEQUENCE UNCERTAINTY PROJECT

Kevin M. Miller

By invitation, EML was selected to participate, under contract, on an expert panel to support the joint United States Nuclear Regulatory Commission/Commission of European Communities Consequence Uncertainty Project. This particular panel dealt with deposited materials and related doses associated with accidental releases from commercial nuclear power plants (NRC, 1995). A formal expert elicitation process was used to provide an evaluation of the radiological consequences occurring off site using previously developed uncertainty methods. A library of distributions is being developed and quantified so that the models used in consequence codes may be evaluated for fundamental flaws in physics, data uncertainties, and stochastic uncertainties in observational data and input parameters. The panel was called together for two meetings which were held in Albuquerque, NM, and hosted by Sandia National Laboratory. Training on the elicitation of expert judgments as probability distributions was given to the panel members and case structure documentation was reviewed. Panel members then prepared a report addressing 13 questions with multiple subparts relating to such matters as radionuclide specific doses as a function of deposition process and time after deposition, location/shielding factors, relative time integrated air concentrations and population characteristics. Estimates of the median and the 5th/95th quantiles of the distributions in the results were derived. Rationale for the computational approach was provided and an oral review session was conducted with project principals. Results of the elicitation are now under review by the project team members and the lead agencies.

Reference

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"Probabilistic Accident Consequence Uncertainty Analysis - Dispersion and Deposition Uncertainty Analysis"
USNRC Report NUREG/CR-6244; EUR 15855EN; SAND94-1453, Vol. 1 (1995)

6.22 THE MULTI-AGENCY RADIATION SURVEY AND SITE INVESTIGATION MANUAL (MARSSIM)

Carl V. Gogolak

The Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) is being developed collaboratively by four federal agencies having authority for control of radioactive materials: Environmental Protection Agency (EPA), Department of Defense (DoD), Department of Energy (DOE), and Nuclear Regulatory Commission (NRC). The manual will provide guidance for planning, conducting, evaluating, and documenting environmental radiological surveys for demonstrating compliance with proposed dose-based regulations for unrestricted release of sites. A multi-step process is being developed for designing and implementing radiation surveys to identify and assess radioactive materials in structures and the environment, to support remediation of radioactive contamination, and to demonstrate compliance with existing regulations. MARSSIM's objective is to describe standardized and consistent approaches for surveys, which will provide a high degree of assurance that established dose-based release criteria, limits, guidelines, and conditions of the regulatory agencies are satisfied at all stages of the process, while at the same time encouraging an effective use of resources. The techniques, methodologies, and philosophies that form the basis of the manual are consistent with current federal limits, guidelines, and procedures. Implementation of surveys entails: (1) the use of commercially available instrumentation and equipment, and (2) survey design and evaluation of results that incorporate standard statistical approaches. EML is participating in the MARSSIM by developing the survey design and statistical analysis procedures and writing the data interpretation chapter of the manual.

6.23 INTERNATIONAL ATOMIC ENERGY AGENCY (IAEA) CONSULTANTS MEETING

Karen A. Stevenson

The IAEA held an advisory meeting (October 9-13, 1995) for the preparation of an IAEA technical document on factors relevant to the development and implementation of characterization methodologies for radioactively contaminated sites. Countries participating in this first of several such meetings included technical representatives from Australia, Canada, Denmark, the United Kingdom, and the United States. The U.S. Department of State selected Karen Stevenson of EML as the U.S. representative. At the conclusion of the meeting, a draft technical document had been produced titled "Guidance on the Characterization of Radioactively Contaminated Site." This draft document will be presented for review and revision at a second meeting currently scheduled for the spring of 1996.